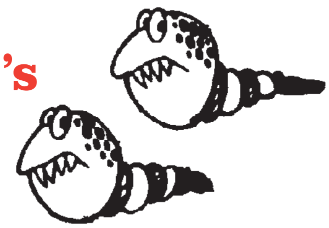
Investigation and Remediation

Natural Attenuation

EPA's New Policy Directive Vis à Vis ASTM's New Industry Standard



by Matt Small and Hal White

Two guidance documents on "natural attenuation" were completed in late 1997—EPA's OSWER Directive titled *Use Of Monitored Natural Attenuation At Superfund, RCRA Corrective Action, And Underground Storage Tank Sites* and the American Society of Testing Materials' (ASTM) standard of practice titled *Guide For Remediation Of Groundwater By Natural Attenuation At Petroleum Release Sites*. Although neither document provides detailed technical guidance, they both offer guidance on evaluating natural attenuation as an appropriate remedial alternative.

The EPA directive is applicable to remediation of contaminated soil and groundwater at sites regulated under all programs administered by EPA's Office of Solid Waste and Emergency Response (OSWER), including Superfund, RCRA Corrective Action, and USTs. It is intended to promote consistency in how monitored natural attenuation (MNA) remedies are proposed, evaluated, and approved for protection of human health and the environment. As a policy document, it provides guidance to EPA and state staff, to the public, and to the regulated community on how EPA intends to exercise its discretion in implementing national policy on the use of MNA.

The ASTM standard is a guide for determining the appropriateness of remediation by natural attenuation (RNA) and implementing RNA at petroleum release sites. Its emphasis is on sites where groundwater is impacted; it does not address situations where contaminated soil exists without an associated groundwater impact. The standard describes a consistent, practical approach to evaluating and utilizing natural attenuation as a remedial alternative in an effort to reduce the costs associated with cleanup of petroleum releases. As an accepted industry code of practice, the standard is intended to be used by environmental consultants, industry, and federal, state, and local regulators involved in response actions at petroleum release sites.

Naturally, there are some differences between the two documents, but these are primarily in tone and emphasis, reflecting the different perspectives and responsibilities of the two entities that developed them. On the whole, the two documents are consistent in their approach to natural attenuation. EPA's policy, however, presents a somewhat more cautious approach, especially in the areas of site characterization, source control, performance monitoring, and contingency plans.

The ASTM document is an industry-consensus standard and should be interpreted as the minimum requirements for adequate demonstration that natural attenuation is an appropriate remedial alternative for a given site. Because EPA's directive represents official regulatory policy, in cases where the two documents are not in agreement, the EPA directive takes precedence over the ASTM standard of practice.

The need for these documents is borne out by the fact that there is little available published information on natural attenuation and that this remedial alternative is being used at thousands of sites nationwide. Scientific understanding of natural attenuation processes continues to evolve rapidly, and significant advances have been made in recent years. However, there is still a great deal to be learned about the mechanisms governing these processes and how they respond to different types of contaminants and hydrogeologic environments. Therefore, a natural attenuation remedy should be used with caution commensurate with the uncertainty associated with a particular situation and only where it will meet remedial objectives that are protective of human health and the environment.

"Natural Attenuation"

The EPA directive distinguishes between "natural attenuation processes" and "monitored natural attenuation" as a remedial alternative. The "natural attenuation processes" that are at work in this type of remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in *situ* processes include biodegradation, dispersion, dilution, sorption, volatilization, chemical or biological stabilization, transformation, and destruction of contaminants.

The term "monitored natural attenuation" is defined as "the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods." Other terms associated with natural attenuation, but not strictly synonymous, include "intrinsic bioremediation," "intrinsic remediation," "passive bioremediation," "natural recovery," and "natural assimilation."

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MONITORED NATURAL ATTENUATION =
"The reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to that offered by other more active methods."

EPA OSWER Directive

While MNA is often dubbed "passive" remediation because it occurs without human intervention, its use at a site does not preclude the use of "active" remediation or the application of enhancers of biological activity (e.g., electron acceptors, nutrients, and electron donors). However, by definition, a remedy that includes the introduction of an enhancer of any type is no longer considered to be "natural" attenuation. Because the directive applies to sites where contaminants other than petroleum constituents (including some that are not biodegradable) may be present, EPA uses the term "monitored natural attenuation" throughout OSWER remediation programs unless a specific process (e.g., reductive dehalogenation) is being referenced.

The ASTM RNA standard makes a distinction between the processes and remedial action that is similar to EPA's directive. Although the RNA definitions for "processes" and "remediation action" sound somewhat more broad, the ASTM standard applies only to petroleum constituents in groundwater. Thus, the definitions are actually more narrowly focused. "Natural attenuation" is defined in the RNA standard as "reduction in mass or concentration of a compound in groundwater over time or distance from the source of contamination due to naturally occurring physical, chemical, and biological processes." Remediation by natural attenuation is defined as "a remedy where naturally occurring physical, chemical, and biological processes will effectively achieve remedial goals. "

REMEDIATION BY NATURAL ATTENUATION =
"A remedy where naturally occurring physical, chemical, and biological processes will effectively achieve remedial goals. "

ASTM Standard

CONTAMINANTS OF CONCERN AND AFFECTED MEDIA

EPA The EPA directive is applicable to a wide variety of sites and potentially unlimited combinations of contaminants and geologic media (including soil) as well as groundwater. Many of the organic contaminants associated with petroleum products are biodegradable, but some are not (e.g., MTBE). Some sites may have organic solvents and other chemicals that are not associated with petroleum fuels. Additionally, RCRA and Superfund mixed-waste sites may have nonbiodegradable inorganic contaminants, including metals and radionuclides. The directive also points out that, in some cases, transformation products may present a greater risk than the parent materials.

ASTM *The ASTM RNA standard clearly states that its emphasis is on the use of remediation by natural attenuation for petroleum hydrocarbon constituents where groundwater is impacted. It does not address situations where contaminated soil exists without an associated groundwater impact. It also states that while much of what is discussed is relevant to other organic contaminants, these situations will involve additional considerations that are not addressed in the guide. The guide emphasizes that care must be taken to ensure that degradation byproducts will not cause harm to human health or the environment. Furthermore, if compounds are present that do not readily attenuate (e.g., MTBE), RNA may not be a suitable remedial alternative or may need to be supplemented with other remedial technologies.*

REMEDY SELECTION CRITERIA

EPA EPA does not consider MNA to be a "presumptive" or "default" remedy; rather the agency advocates using the most appropriate technology for a given site. Determination of the most appropriate technology requires that it meet the applicable statutory and regulatory requirements, that it be fully protective of human health and the environment, and that it meet site remediation objectives within a time frame that is reasonable compared with that offered by other methods.

In general, EPA anticipates that MNA will be used as one component of the total remedy—either in conjunction with active remediation or as a follow-up measure to active remediation—and more rarely as the sole remedy at contaminated sites. Selection of MNA as a remediation method should be supported by detailed site-specific information that demonstrates the efficacy of this remediation approach, including comprehensive site characterization, source control, performance monitoring, and contingency remedies (where appropriate).

ASTM *The ASTM standard specifies that RNA is a remedial action approach that is compatible with existing remedy selection processes but should not generally be considered a presumptive remedy. RNA is not exclusive of other options and should be evaluated in the same manner as other remedial action options for a site. Remedial options should be selected based on their potential to achieve remedial goals.*

Several actions are necessary to determine whether RNA is an appropriate remedial alternative, including site characterization, assessment of potential risks, and evaluation of potential effectiveness similar to other remedial action technologies. The standard explicitly recognizes that there are situations where it is either not necessary or cost-effective to expend resources (e.g., time, money) to undertake a more aggressive approach to remediation.

RNA may be used as a stand-alone option for meeting remedial goals within groundwater if the potential for a near-term impact to an existing receptor is determined to be low. However, if risk-management strategies are not sufficient to *prevent impacts to an identified receptor, then remediation by natural attenuation is inappropriate as a stand-alone option.*

▶ Due to the uncertainty of the effectiveness of natural attenuation, both documents recommend that contingency remedies be identified for implementation should natural attenuation fail to meet remediation objectives.

SITE CHARACTERIZATION

EPA EPA requires that decisions to employ monitored natural attenuation as a remedy or remedy component should be thoroughly and adequately supported with site-specific characterization data and analysis. Site characterizations for natural attenuation generally warrant a quantitative understanding of source mass; groundwater flow; contaminant-phase distribution and partitioning between soil, groundwater, and soil gas; rates of biological and nonbiological transformation; and the variation of all these factors with time. This information is generally necessary because contaminant behavior is governed by dynamic processes that must be well understood before natural attenuation can be applied appropriately at a site.

From this site characterization information, a conceptual model, which provides the basis for assessing potential remedial technologies at a site, can be developed. A conceptual site model is a three-dimensional representation, which may vary over time, that conveys what is known or suspected about contamination sources, release mechanisms, and the transport and fate of those contaminants.

In general, the level of site characterization necessary to support a comprehensive evaluation of MNA is more detailed than that needed to support active remediation. The EPA directive provides a couple of examples where, because of site complexity, MNA may not be an appropriate remedy (e.g., where technological limitations may preclude adequate monitoring or the determination of the pathways of groundwater flow).

ASTM *The ASTM RNA standard states that site characterization must provide the user with adequate information to determine if RNA is a viable remedial option for the site, either by itself or in conjunction with other technologies. Information on site assessment techniques is referenced in other ASTM guides. Because the RNA standard is applicable only to groundwater contamination, the implementation of RNA requires adequate definition of the groundwater plume and understanding of site hydrogeology. The lack of necessary site data or the inability to obtain representative or otherwise requisite samples necessary to construct an acceptable site conceptual model (e.g., aquifer parameters, groundwater and soil chemistry) can preclude appropriate implementation of RNA.*

Specific types of site characterization information that may be necessary to support RNA are listed in an appendix and include lines of evidence (discussed in next section), details about the release, regional and site hydrogeology, locations of nearby receptors, contaminant concentrations, and extent of contamination. The ASTM standard states that technical limitations may obstruct the implementation or progress of RNA and require the consideration or use of other remediation alternatives. Such limitations can include constraints associated with inadequate data used to construct the site conceptual model, the inability to implement the monitoring program, insufficient data to perform predictive modeling, and changes in site conditions.

▶ EPA's directive differs from the RNA standard in that it conveys the unequivocal message that site characterizations for remedies that propose to use natural attenuation should be necessarily more detailed than those for active remediation technologies.

EVIDENCE OF NATURAL ATTENUATION

EPA The EPA directive outlines three lines of evidence that can be used to evaluate the efficacy of MNA as a remedial approach:

1. Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points;
2. Hydrogeologic and geochemical data that demonstrate the types and rates of natural attenuation processes active at the site; and
3. Data from field or microcosm studies conducted with contaminated site material that demonstrate the occurrence of biological degradation processes (for biodegradable components only).

Unless EPA or the implementing agency determines that evidence from item #1 is sufficient to support a decision that the use of MNA is appropriate, then evidence from item #2 should be provided. Evidence from item #3 is generally required when evidence from items #1 and #2 is inadequate or inconclusive.

Where contaminants are not readily degraded through biological processes, where toxic and/or mobile transformation products are formed, or where groundwater and soil chemistry data have been collected for only a short time, more supporting information may be required. It is the responsibility of the regulatee to provide the evidential data to EPA or the appropriate implementing agency.

ASTM *The RNA standard defines its three lines of evidence as follows:*

1. *Observed reductions in concentrations of the compounds of concern in the field (the primary line of evidence for RNA);*
2. *Geochemical indicators of naturally occurring degradation and estimates of attenuation rates (secondary line of evidence); and*
3. *Microbiological information and more sophisticated analysis of primary and secondary lines of evidence such as modeling or estimates of assimilative capacity (additional optional lines of evidence).*

The first line of evidence is the primary line of evidence and is required to demonstrate RNA. The decision to collect secondary and optional lines of evidence should be based on the intended use of the data. The cost benefit of obtaining these

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lines of evidence should also be considered. The primary lines of evidence include concentration data for the compounds of concern at the site, used to define the plume as shrinking, stable, or expanding. For sites where there are sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate RNA.

As for secondary lines of evidence, the standard states that if the primary lines of evidence are inconclusive, it may be necessary to obtain secondary lines of evidence. For those sites where assessment and data collection efforts have recently been initiated, it may be appropriate to supplement the primary lines of evidence with geochemical indicator data. The primary line of evidence is still required at these sites and must be built through data collection over time.

▶ Thus, both documents outline three essentially identical lines of evidence, but EPA's directive promotes collection of first and second lines of evidence as a general rule, while the RNA standard requires the first line of evidence to demonstrate natural attenuation.

GROUNDWATER PLUME STATUS

EPA The EPA directive addresses the issue of plume status by noting that MNA would more likely be appropriate if the plume is not expanding nor threatening downgradient wells or surface water bodies. MNA should not be used where significant contaminant migration or unacceptable impacts to receptors would result. The most appropriate candidate sites for MNA remedies are those where contaminant plumes are no longer increasing in size or are shrinking in size.

ASTM *The ASTM standard requires that the dissolved petroleum plume be categorized as shrinking, stable, or expanding based on historical contaminant concentrations (first line of evidence) obtained from monitoring wells. For sites where there are sufficient historical monitoring data, the primary lines of evidence will often be adequate to demonstrate RNA. A minimum of four monitoring events will likely be required to evaluate the plume status.*

The standard explains that it may be necessary to obtain additional monitoring data before a plume can be defined as stable or shrinking and outlines the implications of the three plume categories as follows:

1. *A shrinking plume is evidence of natural attenuation;*
2. *A stable plume is evidence of natural attenuation; and*
3. *In the case of an expanding plume, the contaminant mass loading rate to groundwater exceeds the natural attenuation rate. It is important to continue to monitor the expanding plume.*

With regard to RNA as an appropriate remedy, the performance of RNA is generally acceptable if a plume is shrinking or stable (primary line of evidence) and there are no impacts to receptors. If a plume is expanding but at a rate lower than the groundwater velocity, the risk reduction and performance goals may be met depending on the presence and location of receptors.

▶ At first glance, both documents seem to be in harmony on this issue. However, there is potentially significant divergence in two areas. First, the RNA standard states that natural attenuation is occurring where a plume is shrinking or *stable*. However, RNA may be appropriate at sites where the plume is shrinking, stable, or expanding, as long as the requirements for no receptor impacts are met, as discussed earlier. EPA's directive takes a somewhat more cautious position in recommending that monitored natural attenuation may be appropriate where a plume is shrinking or *no longer expanding*. The difference between these two conditions is EPA's implicit assumption that where a plume is no longer expanding, it is shrinking. When a plume is stable, there is the implication that the source is continuous, which is usually unacceptable from a regulatory perspective.

Second, the RNA standard states that it is important to continue to *monitor* an expanding plume. This approach allows for application of RNA at sites where it is anticipated that the plume will stabilize within limits that are appropriate for risk management and will eventually begin to shrink. From the EPA MNA directive perspective, an expanding plume indicates that natural attenuation is not effective and that a more aggressive remediation technology (the "contingency remedy") should be implemented.

REMEDIATION TIME FRAME

EPA The EPA directive recognizes that defining a reasonable time frame for achieving remediation objectives is a complex and site-specific decision and that, in general, time frames are longer for MNA than for active remediation technologies. Additionally, because of these extended time frames, hydrogeologic conditions and plume behavior can also change. Factors that influence the determination of what is a reasonable time frame include:

- The relative time frame in which affected portions of an aquifer are needed for future water supplies;
- The classification and value of affected resource(s);
- Uncertainties in the data, assumptions, and predictive analyses (e.g., travel time for contaminants to reach receptors);
- Reliability of monitoring and institutional controls; and
- Public acceptance of the extended time for remediation.

In addition, state groundwater protection programs should be consulted for guidance and requirements. A careful analysis of such factors should enable an environmental agency to determine whether a MNA remedy will fully protect potential human and environmental receptors and whether site remediation objectives and the time needed to meet them are acceptable. When these conditions cannot be met using MNA, a remedial alternative that does meet them should be selected instead.

ASTM *The RNA standard also recognizes that time frames for achieving remedial goals can be relatively long. A long* *period of time may be required to remediate heavier petroleum products. RNA may take longer to mitigate contamination than more aggressive remedial measures do. Thus, RNA may not always achieve the desired cleanup levels within a manageable time frame. The longer time frame, therefore, may require the use of institutional controls to manage and prevent exposures.*

If, on the other hand, RNA is likely to meet the remedial goals within the desired time frame, then it is a viable alternative. However, if the probability of RNA meeting remedial goals is low or uncertain, then supplementary or alternative remedial action measures may be appropriate. The time frame for achieving remedial goals is an important criterion for comparison of RNA with other remedial options. The standard cautions that care should be exercised in estimating remediation time frames for other remedial options so as to not bias the comparison with overly optimistic representations of cleanup time frames.

▶ There is essentially no difference between the EPA directive and ASTM's standard on this issue. Both acknowledge potentially extended time periods for natural attenuation to meet remediation objectives as well as potential need for more aggressive ("contingency") remedies should natural attenuation fail to meet remediation objectives within a reasonable (or "manageable") time frame.

SOURCE CONTROL

EPA EPA expects that source control measures will be evaluated for all sites under consideration for any proposed remedy, especially where MNA is under consideration as the remedy or as a remedy component. The need for such evaluation is largely a reflection of the uncertainty associated with the potential effectiveness of MNA to meet remedial objectives that are protective of human health and the environment within a reasonable time frame.

Source control measures include removal, treatment, or containment measures (e.g., physical or hydraulic control of areas of the plume in which NAPLs are present in the subsurface). EPA prefers remedial options that remove or treat contaminant sources when such options are technically feasible. The need for source control is clear—contaminant sources that are not adequately addressed complicate the long-term cleanup effort by leaching significant quantities of contaminants into the groundwater, which can extend the time necessary to reach remedial objectives.

EPA believes that control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. Following source control measures, monitored natural attenuation may be sufficiently effective to achieve remediation objectives at some sites without the aid of other (active) remedial measures. Typically, however, monitored natural attenuation will be used in conjunction with active remediation measures even at petroleum release sites.

ASTM *The ASTM standard states that an evaluation of the need for source area control measures should be integrated into remedial decision-making at all sites where RNA is under consideration. Source area control measures include physical removal, treatment, and stabilization. The standard acknowledges that the RNA option is subject to approval by the regulatory agency responsible for the oversight of the cleanup of the petroleum release and source area control decisions.*

▶ Perhaps the most significant difference between EPA's directive and ASTM's standard is EPA's emphasis on the need for source control (including free product recovery). Federal regulations (specifically 40 CFR 280.64), which are acknowledged by the ASTM standard, require that free product be recovered to the maximum extent practicable as determined by the implementing agency. EPA's directive advocates source control measures in all cases, but especially when employing natural attenuation, so that remediation time frames are not unacceptably extended. EPA also expresses a preference for source control measures that remove or treat sources rather than merely contain them.

PERFORMANCE MONITORING

EPA The EPA directive includes the term "monitored" when referring to a remedy that utilizes natural attenuation processes to emphasize that this is not a "do-nothing" or "walk-away" remedial option—long-term performance monitoring is an essential component of MNA and any other remedial option. Use of MNA does not imply that activities (and costs) associated with investigating the site or selecting the remedy (including performance monitoring) have been eliminated. These elements of the investigation and cleanup must still be addressed as required under the particular OSWER program, regardless of the remedial approach selected.

MNA will not generally be appropriate where site complexities preclude adequate monitoring or in cases where the associated costs are high compared with the cost of active remediation technologies. While performance monitoring to evaluate the effectiveness of a remedy and to ensure protection of human health and the environment is a critical element of all response actions, it is of even greater importance for MNA because of its longer remediation time frames, potential for ongoing contaminant migration, and other uncertainties.

The monitoring program developed for each site should specify the location, frequency, and type of samples and measurements necessary to evaluate remedy performance as well as define the anticipated performance objectives of the remedy. In addition to verifying the attainment of cleanup objectives, an adequate monitoring program should identify any potentially toxic transformation products resulting from biodegradation, determine if a plume is expanding (either downgradient, laterally or vertically), ensure adequate warning of potential impact to downgradient receptors, detect new releases of contaminants to the environment that could have an impact on the effectiveness of the natural attenuation remedy, demonstrate the efficacy of institutional controls that were put in place to protect potential receptors, and detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes.

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Typically, performance monitoring is continued for a specified period (e.g., 1 to 3 years) after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels. The institutional and financial mechanisms for maintaining the monitoring program should be clearly established in the remedy decision or other site documents, as appropriate.

ASTM *The ASTM standard acknowledges that implementation of RNA requires demonstration of remedial progress and attainment of remedial goals through monitoring. The inability to obtain representative or otherwise requisite samples necessary to design an adequate long-term monitoring plan can preclude appropriate implementation of RNA. According to the standard, once an RNA option is selected, it is necessary to develop and implement a monitoring program that is both capable of yielding adequate information to evaluate the progress of RNA in meeting remedial goals and cost-effective.*

The cost associated with monitoring may well be the most expensive part of a natural remediation project. The objectives of the monitoring program are defined as:

- *Evaluating performance and progress of RNA toward meeting remedial goals, and*
- *Ensuring that the plume is not migrating to an extent greater than expected.*

The standard states that the monitoring program should include appropriate sampling locations, adequate sampling frequency, and meaningful sampling parameters and that it should include sufficient groundwater monitoring wells, both in number and location, to determine changes in groundwater flow directions and velocities, trends in contaminant concentrations within the plume (over time and/or distance), and any further migration of the plume.

According to the standard, although monitoring frequency is a site-specific consideration, it should be at least quarterly for a minimum of 1 year so as to define seasonal fluctuations in contaminant concentrations, water table elevations, and hydraulic gradients. The lack of these data could make it very difficult or impossible to adequately resolve concentration trends in subsequent data sets.

Where variability in concentration of the compounds of concern precludes the resolution of any trends, or if monitoring data do not indicate significant natural attenuation, then the standard recommends that geochemical indicator parameters be evaluated in addition to the primary line of evidence. Monitoring results should be evaluated to determine progress toward meeting remedial goals.

If remedial goals are met, then no further action is required. If remedial goals are not met, RNA remedial progress should continue to be evaluated. When remedial goals have been achieved, and further monitoring is no longer required to ensure that conditions persist, then no further action is necessary, except to ensure that institutional controls (if any) remain in place, and regulatory concurrence should be pursued.

▶ There are no major differences with regards to performance monitoring. However, EPA cautions that monitoring generally should continue for 1 to 3 years after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels.

REMEDIATION OBJECTIVES

EPA EPA has responsibility for establishing site-specific remediation objectives that are fully protective of human health and the environment. In the EPA directive, remediation objectives are defined as the overall objectives that remedial actions are intended to accomplish and are not the same as chemical-specific cleanup levels. Remediation objectives could include preventing exposure to contaminants, minimizing further migration of contaminants from source areas, minimizing further migration of the groundwater contaminant plume, reducing contamination in soil or groundwater to specified cleanup levels appropriate for current or potential future uses, and other goals. EPA supports the use of risk-based decision-making in establishing remedial goals for UST corrective actions (OSWER Directive 9610.17).

ASTM *The ASTM standard advocates that remedial goals be determined by applying the risk-based corrective action process in [ASTM] Guide E 1739 or another state-approved method. Remedial goals established to protect human health and the environment may take the form of concentration target levels at specific points or performance criteria, such as demonstration that the petroleum hydrocarbon plume has been contained. Remedial goals may also have some time frame associated with them.*

In general, the ASTM risk-based approach requires that the potential for impacts to human health and the environment be determined by conducting surveys of primary and secondary sources, transport mechanisms, viable exposure pathways, and potential receptors. Target levels must be either an achievable numeric value or other performance criteria that protect human health, safety, and the environment.

In general, RNA is more amenable to achieving performance-based goals, such as demonstrated containment of the groundwater plume or demonstrated reduction in contaminant concentrations over time within the plume or with distance from the source area.

▶ Both documents are in harmony with regard to remediation objectives. However, the ASTM standard defines remedial goals that are applicable only to UST release sites, while EPA's directive is designed for a broader class of contaminated sites.

CONTINGENCY REMEDIES

EPA EPA recommends that remedies employing monitored natural attenuation be evaluated to determine the need for including one or more contingency measures that would be capable of achieving remediation objectives. EPA believes that a contingency measure may be particularly appropriate for a monitored natural attenuation remedy that has been selected based primarily on predictive analysis (the second and third lines of evidence discussed previously) as compared with natural attenuation remedies based on historical trends of actual monitoring data (the first line of evidence).

According to the directive, contingency remedies should be employed where the selected technology is not proven for a specific site application, where there is significant uncertainty regarding the nature and extent of the contamination at the time the remedy is selected, or where there is uncertainty regarding whether a proven technology will perform as anticipated under the particular circumstances of the site.

Criteria that may trigger implementation of the contingency remedy include:

- An increasing trend in contaminant concentrations in either groundwater or soil at sampling locations;
- Evidence of a new or renewed release;
- Discovery of contaminants in sentry/sentinel wells located outside of the original plume boundary (indicating renewed contaminant migration);
- Contaminant concentrations that are not decreasing at a sufficiently rapid rate to meet the remediation objectives; and
- Changes in land and/or groundwater use that will adversely affect the protectiveness of the monitored natural attenuation remedy.

ASTM *The RNA standard states that if it is shown that RNA is not solely sufficient to provide adequate protection of potential receptors, the data collected for the RNA study can be used to design supplemental remedial alternatives. If remedial progress does not match estimates, RNA should be reevaluated as to whether it is an appropriate remediation option for the site. If at any point during the long-term monitoring program, data indicate that natural attenuation is not adequate to contain the plume, the contingency plan should be implemented.*

▶ Again, there are no major conflicts between EPA's directive and ASTM's standard. The EPA directive is somewhat more adamant about the need for considering contingency remedies at the beginning of the site evaluation process rather than later, when it may be too late for the contingency remedy to be protective of human health and the environment.

NO FURTHER ACTION

EPA The EPA directive recommends that performance monitoring should continue as long as contamination concentrations exceed the required cleanup levels. It recommends that performance monitoring be continued for a specified period (e.g., 1 to 3 years) after cleanup levels have been achieved to ensure that concentration levels are stable and remain below target levels. It also recommends that institutional and financial mechanisms for maintaining the monitoring program be clearly established in the remedy decision or other site documents, as appropriate.

ASTM *The ASTM standard states that when it can be demonstrated that target cleanup levels or performance-based criteria for a site have been achieved, and further monitoring is no longer required to ensure that conditions persist, then no further action is necessary. Mechanisms or procedures must be implemented to ensure that institutional controls (if any) remain in place. Regulatory concurrence should be pursued on a determination of no further action.*

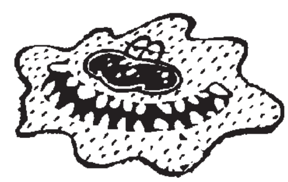
The ASTM standard lists four key criteria for no further action at a site that has undergone remediation by natural attenuation:

- *There are no existing or potential receptor impacts;*
- *Remedial goals have been met, or it has been demonstrated that natural attenuation will continue and ultimately meet remedial goals;*
- *The plume is stable or shrinking; and*
- *If needed, institutional controls are in place and maintained.*

If natural attenuation is demonstrated to be effective at a site, and site conditions will not change, natural attenuation will continue to serve as an ongoing remedial action regardless of whether it is monitored.

▶ Both documents recommend that monitoring be continued to ensure that conditions persist. However, the ASTM standard allows for a determination of no further action prior to actually meeting remedial goals if it has been demonstrated that natural attenuation will continue and ultimately meet remedial goals. This idea means that, in some cases, the implementing agency could approve termination of monitoring before remedial goals are met. The EPA MNA directive takes a more conservative approach, recommending that performance monitoring continue as long as contamination concentrations exceed the required cleanup levels. Once cleanup levels are met, the directive recommends additional monitoring to ensure that conditions persist. (See chart on page 12.)

To Obtain the Standards...



The EPA OSWER directive, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive 9200.4-17, is available in several electronic formats from EPA's web site; the address is: http://www.epa.gov/swerust1/directiv /d9200417.htm.

The anticipated approval date for the ASTM standard of practice, *Guide For Remediation Of Groundwater By Natural Attenuation At Petroleum Release Sites*, is March 10, 1998. As of press time, no designation has been assigned the standard. Please check the ASTM web page, www.astm.org, to obtain up-to-date information. For information about ASTM or the work of committee E-50 (for UST/LUST-related work), contact Susan Canning at (610) 832-9714. ■

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Hal White is with the U.S. EPA Office of Underground Storage Tanks in Washington, D.C. and is Co-chair of the OSWER MNA Workgroup. He may be contacted at white.hal@epamail.epa.gov. *No official support or endorsement by the Environmental Protection Agency or any other agency of the federal or state government is intended or should be inferred. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.*